

WHAT IS CLAIMED IS:

1. A method of depositing an Atomic Layer Deposition film on a substrate, comprising the steps of

(a) passing the substrate through a first enclosure defining a first reactive zone, the first reactive zone containing a first reactive gas at a first, reactive zone pressure, the first reactive zone being in fluid communication with a first exhaust zone, the first exhaust zone further being in communication with a buffer zone defined by an outer enclosure, the outer volume containing a neutral gas at a second, buffer zone pressure, the total pressure of gas in the first exhaust zone being a third, exhaust zone pressure, the first, reactive zone pressure being greater than the third, exhaust zone pressure, the second, buffer zone pressure being greater than the third, exhaust zone pressure and the second, buffer zone pressure being greater than or equal to the first, reactive zone pressure, and

(b) passing the substrate through a second enclosure defining a second reactive zone, the second reactive zone containing a second reactive gas at a fourth, reactive zone pressure, the second reactive zone being in fluid communication with a second exhaust zone, the second exhaust zone further being in communication with the buffer zone defined by the outer enclosure, the total pressure of gas in the second exhaust zone being a fifth, exhaust zone pressure, the fourth, reactive zone pressure being greater than the fifth, exhaust zone pressure, the second, buffer zone pressure being greater than the fifth, exhaust zone pressure, and the second, buffer zone pressure being greater than or equal to the fourth, reactive zone pressure.

2. The method of claim 1, wherein the substrate is placed on a movable susceptor, the susceptor carrying the substrate as it passes through the reactive zones.

3. The method of claim 1, wherein at least one reactive zone and its attached pumping zone is heated above room temperature.

4. The method of claim 3, wherein the reactive zone and its attached exhaust zone are kept at a temperature below the substrate temperature, the difference between 1) the substrate temperature and 2) the temperature of the reactive zone and attached exhaust zone being no more than 50°C.

5. The method of claim 1, wherein the third, exhaust zone pressure is at least 90% of the first, exhaust zone pressure, and the fifth, exhaust zone pressure is at least 90% of the fourth, reactive zone pressure.

6. The method of claim 1, wherein the third, exhaust zone pressure is at least 95% of the first, exhaust zone pressure, and the fifth, exhaust zone pressure is at least 95% of the fourth, reactive zone pressure.

7. The method of claim 1, wherein the first exhaust zone is defined by a first exhaust pipe and the second exhaust zone is defined by a second exhaust pipe, and at least one of the first and second exhaust pipes extends at least 0.5 meters along the gas flow axis.

8. The method of claim 1, wherein the exhaust zones are connected to independent exhaust pipes leading to independent pumps, the third and fifth exhaust pressure values being kept independent.

9. The method of claim 7, wherein at least in one of the exhaust pipes that join before a common pump, a pressure regulation system ensures a process pressure higher in the corresponding reactive zone than the pressure in the other reactive zone.

10. The method of claim 2, wherein the susceptor rotates on an axis at a constant angular speed at least during passing of a substrate through a reactive zone.

11. The method of claim 10, wherein one of the reactive gases is injected into one of the reactive zones in a distributed manner along the susceptor's radius of rotation.

12. The method of claim 11, wherein the reactive gas is injected into the reactive zone at each injection point at a rate proportional to the length of the radius measured to the injection point.

13. The method of claim 11, wherein the reactive gas is injected so as to flow in contact with the susceptor and in the direction of the susceptor's rotation.

14. The method of claim 13, wherein the local average parallel velocity of the reactive gas flow in contact with the susceptor is at least 35% of the local substrate velocity.

15. The method of claim 1, further comprising the step of passing the substrate through a skimming zone where a neutral gas is flown after passing the substrate through one of the reactive zones.

16. The method of claim 13, wherein step (a) and step (b) are repeated alternately, and wherein the step of passing the substrate through a skimming zone is performed between each performance of each step (a) and each step (b).

17. The method of claim 15, wherein a sequence of step (a) and step (b) is repeated and wherein the step of passing the substrate through a skimming zone is performed between each performance of the sequence.

18. The method of claim 16, wherein after a first layer of ALD film has been formed on the substrate, process conditions are changed so as to form a different layer of ALD film on the substrate.

19. The method according to claim 1, wherein at least one of reactive gases is excited by a plasma.

20. The method according to claim 1 wherein at least one of the reactive zones is exposing the substrate to activating agents such as radicals, excited atoms or molecules, photons, electrons or ions.

21. The method according to claim 1, wherein a measurement means is used to monitor a substrate property.

22. The method according to claim 21, wherein a control means automatically adjusts a process parameter in response to output of the measurement means.

23. The method of claim 1 wherein at least one of the exhaust zones is disposed as an annulus fully surrounding its process zone.

24. A CVD-ALD apparatus comprising:

- an outer enclosure;
- a first exhaust pipe having a first end located inside the outer enclosure;
- a second exhaust pipe having a first end located inside the outer enclosure;
- a first reaction enclosure located inside the outer enclosure and in fluid communication with the first exhaust pipe, the first reaction enclosure defining an opening;
- a second reaction enclosure located inside the outer enclosure and in fluid communication with the second exhaust pipe, the second reaction enclosure defining an opening;
- a susceptor disposed adjacent to the first end of the first exhaust pipe, the first end of the second exhaust pipe, the opening of the first reaction enclosure, and the opening of the second reaction enclosure;
- a neutral gas supply;
- a means for supplying a first reaction gas to the first reaction enclosure; and
- a means for supplying a second reaction gas to the second reaction enclosure.

25. The apparatus according to claim 24, further comprising:

- a first reaction gas at a first, reactive zone pressure in the first reaction enclosure;
- a neutral gas at a second, buffer zone pressure in a buffer zone in the outer enclosure;
- a first exhaust gas at a third, exhaust zone pressure in the first exhaust pipe;
- a second reaction gas at a fourth, reaction zone pressure in the second reaction enclosure; and
- a second exhaust gas at a fifth, exhaust zone pressure in the second exhaust pipe;

wherein the second, buffer zone pressure is greater than the third, exhaust zone pressure, the second, buffer zone pressure is greater than the fifth, exhaust zone pressure, the first, reaction zone pressure is greater than the third, exhaust zone pressure, and the fourth, reactive zone pressure is greater than the fifth, exhaust zone pressure.

26. The apparatus according to claim 25, wherein the second, buffer zone pressure is greater than or equal to the first, reactive zone pressure, and the second, buffer zone pressure is greater than the fourth, reactive zone pressure.

27. The apparatus according to claim 24, wherein the first end of the first exhaust pipe and the susceptor define a first conductance slit.

28. The apparatus according to claim 24, wherein the first end of the second exhaust pipe and the susceptor define a second conductance slit.

29. The apparatus according to claim 27, wherein each of the conductance slits has essentially a constant width along the exhaust zone outer periphery.

30. The apparatus according to claim 28, wherein each of the conductance slits has essentially a constant width along the exhaust zone outer periphery.

31. The apparatus according to claim 29, wherein the width of each conductance slit is 0.3-1.5 mm.

32. The apparatus according to claim 30, wherein the width of each conductance slit is 0.3-1.5 mm.

33. The apparatus according to claim 24, wherein the first exhaust pipe and the second exhaust pipe join together outside of the outer enclosure, and the extent of one of the exhaust pipes between its first end and the location where the pipes are joined is at least 0.5 m.

34. The apparatus according to claim 24, wherein the susceptor is rotatably mounted on a spindle.

35. The apparatus according to claim 34, wherein the first gas distribution means and the second gas distribution means each comprise means for distributing gas along the susceptor's rotation axis.

36. The apparatus according to claim 24, wherein a surface of the susceptor defines a plurality of recesses for receiving substrates, the recesses being sized so that the exposed surface of each substrate and the surface of the susceptor are within 0.2 mm of being at the same level.